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Degradation mechanisms of composite cathode on anode-supported solid oxide fuel cells under various operating conditions

Tae-Hee Lee, Ka-Young Park, Seung-Seok Baek, Ji-Tae Kim, Jun-Young Park *

Department of Nanotechnology and Advanced Materials Engineering, Sejong University, Gunja-dong, Gwangjin-gu, Seoul, 143-747, Republic of Korea

Solid oxide fuel cells (SOFCs) have many advantages compared to traditional fuel cells, such as high efficiency, high power density, environmental friendliness, flexibility in using fuel and no noble metal catalysts. Performance, durability, and cost are important aspect for the research in the field of SOFCs. However, the study of durability is only in the early stages compared to the effort of reducing operating temperature and improving performance. In order to practical use of SOFCs it becomes more and more significant to acquire knowledge about the impact on durability of SOFCs under various operating conditions, such as flow rate of gas, amount of humidification, a sort of fuel, and operating temperature, etc. also, for having long-term stability of SOFCs, the properties of high electric and ionic conductivity, high catalytic activity, chemical and thermal compatibility with the electrolyte, and chemical stability in an oxidizing atmosphere are required to a cathode material. Therefore, for high performance and enhanced durability of SOFC, it is necessary to understand of degradation mechanism for cathode and it must be carried out first of all.

In this work, NiO is used to commercial powder and $Ce_{0.9}Nd_{0.1}O_{2-\delta}$ (NDC) is synthesized by glycine-nitrate combustion process for electrolyte. NiO-NDC powder is mixed as 65:35 wt% by ball-milled for 24 h and dried. The composite powder is prepared as anode substrate. For deposition of the electrolyte, the prepared NDC slurry is dip-coated onto the one side surface of anode support and is dried at room temperature. The bi-layered sample is co-sintered at 1,550℃ for 4 h using a 2 ℃min-1 ramp rate in air. To view impact of durability depending on the complexity of microstructure, $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF), $NdBa_{1-x}Sr_xCo_{2-y}Fe_yO_{5+\delta}$ (NBSCF) powder is prepared as cathode material by nano-powder synthesis method. Cathode electrode is composed of both cathode material and NDC powder and coated by screen printing method. The cathode is fired at 1,100℃ for 1 h, Finally. A prepared cell is loaded on a reactor, and then is measured initial electrochemical properties at various operating conditions (as mentioned earlier) in measurement station by electrochemical analyses. Figure 1 show the SEM image of surface and cross sectional view of a performed sample. As seen in figures 1 (a) and (b), small pores are observed in the layer of electrolyte. However, the surface view of electrolyte shows no pinhole. The thickness of the electrolyte is estimated to be about 10μm form the SEM image. Both anode and cathode is formed porous and suitable for gas transport.

Henceforward, Long-term durability of single cells is carried out under constant current according to periodically on/off of air flow on cathode side. In addition, degradation mechanisms of SOFCs are studied to understand effect of the long-term processes under other operating conditions by electrochemical analysis and physicochemical analysis.

1. Ceria-based solid electrolytes, Hideaki Inaba, Hiroaki Tagawa, *Solid state ionics*, **83**, 1 (1996).
2. Lowering the Temperature of Solid Oxide Fuel Cells, Eric D. wachsman, and Kang Taek Lee, *Science*, **334**, 935 (2011).
3. Performance of IT-SOFC with $Ce_{0.9}Gd_{0.1}O_{1.95}$ functional layer at the interface of $Ce_{0.9}Gd_{0.1}O_{1.95}$ electrolyte and Ni-$Ce_{0.9}Gd_{0.1}O_{1.95}$ anode, J.S.Ahn, H.Yoon, K.T.Lee, M.A.Camaratta, E.D.Wachsman, *J. Fuel cells*, **9**, 643 (2009).
4. Facile autocombustion synthesis of $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) perovskite via a modified complexing sol–gel process with NH_4NO_3 as combustion aid, Lei Ge, Wei Zhou, Ran Ran, Zongping Shao, Shaomin Liu, *J. Alloys and Compounds*, **450**, 338 (2008)
5. Gel-combustion synthesis of $La_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_{3-\delta}$ and measurement of its humidity-dependent electrical conductivity, R. Sundaram, K.S.Nagaraja, *J. Materials Science*, **39**, 3509 (2004)
6. Chemical and thermomechaniclal compatibility between Ni-GDC anode and electrolytes based on ceria, V.Gil, J.Tartaj, C. Moure, *J. Ceramics International*, **35**, 839 (2009)
7. Effect of cathode gas humidification on performance and durability of solid oxide fuel cells, J.Nielsen, A. Hagen, Y.L.Liu, *Solid state ionics*, **181**, 517 (2010)

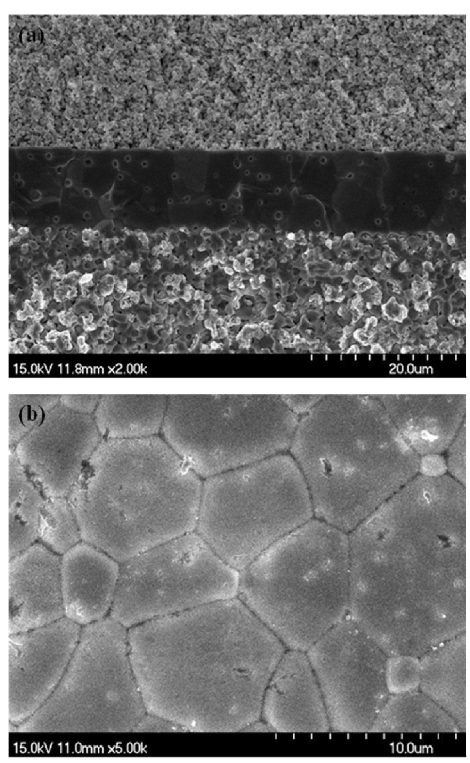

Fig.1. SEM photographs of the anode supported SOFC: (a) a surface of NDC electrolyte, (b) a cross-sectional view of three-layer structure after cell performance measurement